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**Slide 1**

# Planetary Probe
## A Graphing Puzzle of Space Exploration
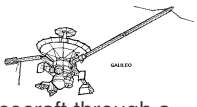http://microgravity.grc.nasa.gov/outreach/navigator/game.html

VOYAGER

*by*
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**Slide 2**

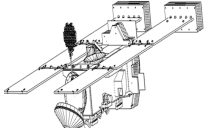# What is **Planetary Probe?**

GALILEO

- A paper & pencil puzzle.
- A scored contest.
- The imaginary flight of a spacecraft through a planetary system.
- A way to learn about spaceflight, gravity, and forces & motions.

- *An introductory game to prepare you for the* **Spaceship Commander** *game.*

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**Slide 3**

# **Planetary Probe** Objective

- Win by ending the game with the most points.
- Earn points by conducting surveys of planets.

- **Win by flying close to planets!**

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**Slide 4**

# Planetary Surveys

- Spacecraft use cameras and other instruments to make remote measurements of a planet's surface.
- Better measurements are possible when the probe is close to planets.
- Survey points
    +1 per turn endpoint in a non-home □ (gravity well), except during a crash
- Exploration points - *for measurements of different planets*
    +3 per each non-home planet surveyed, with at least one turn endpoint in the planet's □ (gravity well)

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**Slide 5**



PLANETARY PROBE
Sample Game
Home Planet (*circle one*):        E16        F22

Flight Director _____
(*print name above*)

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**Slide 6**
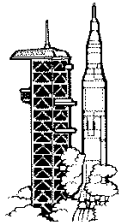
# Navigation

- System map coordinates are given by row letter and column number, for example F16.
- The system map shows several planets:
    ⊙ weak-gravity planet
    ⬤ strong-gravity planet
- ⊡ Each planet is surrounded by a gravity well, where spacecraft are pulled toward the planet.
- ⊡ Planets with stronger gravity have bigger gravity wells.

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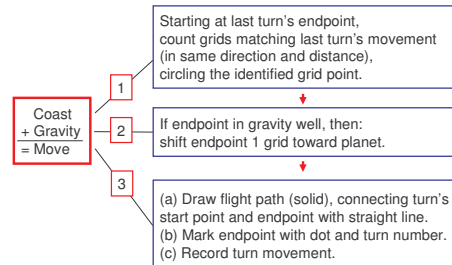
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## Launch  (Turn 1)

- ⊙ On the first turn, the probe launches from its home (starting) planet.
- ▣ The launch endpoint is any grid point just outside the planet's gravity well.
- ⬤ In the game, the spaceship cannot launch from strong-gravity planets.
- Launch cost is free in this game.

- *Landing is **not** allowed, so you can only launch on the first turn.*

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## Turn Sequence  (after launch)

| Coast + Gravity = Move | 1 | Starting at last turn's endpoint, count grids matching last turn's movement (in same direction and distance), circling the identified grid point. |
| | 2 | If endpoint in gravity well, then: shift endpoint 1 grid toward planet. |
| | 3 | (a) Draw flight path (solid), connecting turn's start point and endpoint with straight line. (b) Mark endpoint with dot and turn number. (c) Record turn movement. |

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## Coasting

- The probe moves the same as last turn:
  - same direction
  - same distance
  - unless …
  - the probe crashes,
  - the coast path ends within a gravity well,
    - causing the probe to be pulled one (1) grid toward the planet.

- ***Inertia*** *makes objects tend to stay moving in the same way,*
  - *as explained by Newton's First Law of Motion.*
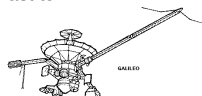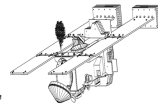
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## Crashing

- The probe crashes if:
  - turn's endpoint is at a planet grid,
  - turn's flight path exactly crosses a planet grid point.
    - A flight path which does not exactly cross the planet grid point does **not** result in a crash, even if the flight path crosses the planet symbol (circle).
- There is no penalty or bonus for crashing.
  - Points are not earned on a crash turn.
- Crashing ends the game.

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## Turning the Probe

- The probe does not have engines, but gravity will change its flight path.
- If the probe is **not** in a gravity well (▫),
  - then it **cannot change directions** and must go in a straight line at a constant speed,
    - duplicating last turn's movement.
- If the probe is in a gravity well (▫),
  - then it is shifted one (1) grid toward the planet.

- *The **only** decision in this introductory game is the choice of launch direction on the first turn.*

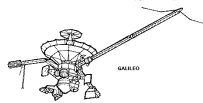2004/10/19      11

## Game End

- The game ends when:
  - probe crashes,
  - probe's coast path goes outside the map's boundaries.
- There is no penalty or bonus for either end.
  - Points are not earned during the turn that the probe crashes or flies outside the boundaries.

- Total the scores to find out who won!

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## Scoring

- Exploration
  - +3 per each non-home planet surveyed, with at least one turn endpoint in the planet's □ (gravity well)
- Survey
  - +1 per turn endpoint in a non-home □ (gravity well), except during a crash


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- **This game is a puzzle, and you are allowed to erase and "do over."**

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## Planetary Probe Q&A

Q: How far does the probe move?
A: Same as last turn, unless shifted by gravity.

Q: Which direction does the probe move?
A: Same as last turn, unless shifted by gravity.

Q: When does gravity shift the probe?
A: When the coast path **ends** within gravity well (□).

Q: In what direction does gravity shift the probe?
A: One (1) grid toward planet, as shown by markings on system map.

Q: Can the spaceship come to a stop?
A: Yes.  Gravity can cause the spaceship to lose speed and come to a complete stop.  When this happens, there is no coasting motion on the following turn.  Otherwise, all normal rules apply.

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## Spaceship Commander
### A Graphing Puzzle of Space Exploration

http://microgravity.grc.nasa.gov/outreach/navigator/game.html



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## Game Differences & Similarities
Spaceship Commander (SC) vs. Planetary Probe* (PP)

**DIFFERENCES**

| PP | SC | Attribute |
|----|----|-----------|
| yes | no | crashing allowed |
| no | yes | engines use on turns after launch (-2 per turn) |
| no | yes | microgravity experiments (+1 per turn coasting) |

**SIMILARITIES**

| PP | SC | Attribute |
|----|----|-----------|
| yes | yes | coasting path due to inertia |
| yes | yes | gravity shift (in □ around planet) |
| yes | yes | surveys (+1 per turn in □ around planet) |
| yes | yes | exploration (+3 per each non-home planet surveyed) |

*Planetary Probe (PP) = introductory game

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## Spaceship Commander Objective

- Win by ending the game with the most points.
- Earn points by conducting:
  - Surveys of different planets,
  - Microgravity experiments.
- Lose points for:
  - Fuel when you use your spaceship's engines after launch.

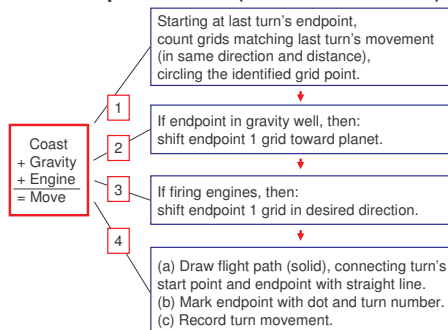- **Win by flying close to planets!**
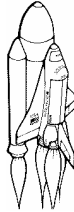
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## Microgravity

- Microgravity is the condition where gravity **seems** to be very low, because:
  - gravity **is** very low,
  - **or** the spaceship (or object) is in free fall.
- Spaceships are in free fall and experience microgravity whenever they are coasting and don't use their engines,
  - like the Space Shuttle as it orbits Earth.
- Scientists can make new discoveries when experiments are conducted in microgravity.

- **One (1) point is earned for each turn that the spaceship does not fire its engines.**

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## Turn Sequence  (after launch)

Coast + Gravity + Engine = Move

1. Starting at last turn's endpoint, count grids matching last turn's movement (in same direction and distance), circling the identified grid point.
2. If endpoint in gravity well, then: shift endpoint 1 grid toward planet.
3. If firing engines, then: shift endpoint 1 grid in desired direction.
4. (a) Draw flight path (solid), connecting turn's start point and endpoint with straight line.
(b) Mark endpoint with dot and turn number.
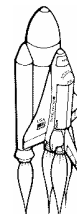(c) Record turn movement.

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## Coasting

- The spaceship moves the same direction and distance as the last turn, unless:
  - the coast path ends within a gravity well (but not at the planet), causing the spaceship to be pulled one (1) grid toward the planet,
  - the engines are fired.

- **For each turn that the spaceship is coasting:**
  **+1 point for microgravity,**
  **-0 points for fuel.**

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## Using the Engines

- Once per turn, the spaceship can use its engines **after**:
  - (1) coasting,
  - (2) gravitational shift, if in gravity well.
- When engines are used, the endpoint can be shifted one (1) grid in any direction,
  - diagonally, horizontally, or vertically.
- Fuel and speed are both unlimited.

- **For each turn that the spaceship uses its engines:**
  **+0 points for microgravity,**
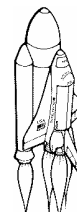  **-2 points for fuel.**
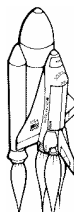
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## Crashing

- Crashing is **not allowed**!
- Engines must be used to avoid:
  - turn's endpoint at a planet grid,
  - turn's flight path exactly crossing a planet grid point.
    - A flight path which does not exactly cross the planet grid point does **not** result in a crash, even if the flight path crosses the planet symbol (circle).

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## Turning the Spaceship

- The spaceship **cannot turn** and must go in a straight line at a constant speed **unless** it**:**
  - is in a gravity well and is shifted one (1) grid toward the planet,
  - uses its engines to shift one (1) grid in any direction,
    - diagonal, horizontal, or vertical.
- The gravity and engine shifts to the coast path are made at the end of the turn in that order.
- The spaceship **cannot** make sharp turns unless it is moving very slowly,
  - because the turn's endpoint can only be shifted one (1) grid each for gravity and the engines.

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## Game End

- The game ends when:
  - end of the pre-selected turn is reached,
  - spaceship's coast path goes outside the map's boundaries,
    - no penalty, but you can't earn more points

- Total the scores to find out who won!

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## Scoring

- Exploration
  - +3 per each non-home planet surveyed, with at least one turn endpoint in the planet's □ (gravity well)
- Survey
  - +1 per turn endpoint in a non-home □ (gravity well), except during a crash
- Microgravity
  - +1 per turn when engines are not used
- After launch, Microgravity and Fuel score as shown here, depending on the use of the engines:

| Engines | off | on |
|---|---|---|
| Microgravity | +1 | +0 |
| Fuel | -0 | -2 |

- **This game is a puzzle, and you are allowed to erase turns and "do over" to earn more points!!!**

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## **Spaceship Commander** Q&A

Q: How much fuel is in the spaceship?
A: Fuel is unlimited (just like the spaceship's speed).

Q: When can the spaceship's engines be fired?
A: Once per turn, following (1) coasting, and (2) the gravity shift, if any.

Q: Are microgravity points earned within gravity wells?
A: Yes. The spaceship experiences microgravity on every turn that the engines are not used, whether it is in a gravity well or not.

Q: Can the spaceship come to a stop?
A: Yes. The spaceship can lose speed, due to gravity and/or engine firings, and come to a complete stop. When this happens, there is no coasting motion on the following turn. Otherwise, all normal rules apply.

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## Notes

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